SCIENCE ABSTRACTS.

Section A.—PHYSICS.

DECEMBER 1918.

GENERAL PHYSICS.

1207. *Hypsometer.* **R. Cozza.** (N. Cimento, 14. pp. 226–233, Nov.–Dec., 1917.)—Describes a pattern of hypsometer with an air thermometer, the latter being adjusted once for all. It is shown how the combination may be applied to measure variations in *g*. A. D.

1208. *Clocks and Time-keeping.* **R. A. Sampson.** (Roy. Soc. Edinburgh, Proc. 38. 1. pp. 75–96, and 38. 2. pp. 97–114 and 169–218, 1917–1918.)—The first part of this paper deals at length with the theory of the maintenance of motion, and discusses in detail the mechanism of the Riefler, Synchronome, and Cottingham clocks. The second part consists essentially of tables of the "circular equation," known technically as the circular error. In subsequent papers it is intended to treat of other necessary points connected with exact time-keeping, such as air-resistance, barometric error, escapement error, temperature compensation, and so forth. A. W.

1209. *Size of Submicroscopic Particles.* **G. Laski.** (Phys. Zeits. 19. pp. 369–378, Sept. 1, 1918.)—Deals further with the method of determining the size of solid particles, of dimensions of the wave-length of light, by means of observations on the colour of the scattered light [Abs. 141 (1918)]. It appears that for sulphur particles from 8×10^{-6} cm. radius to 18×10^{-6} cm. radius the colour ranges from purple through blue and green to yellow. Particles of larger size give a yellowish colour very similar to that of sulphur in the mass. [See Abs. 1196 (1915).] A. W.

1210. *Oil Films on Water.* **G. Ercolini.** (N. Cimento, 15. pp. 49–88, Jan.–Feb., 1918).—Discusses in detail the experimental difficulties of observation; and concludes that it is only known with certitude that the minimum thickness is of the order of a molecular diameter (about 1 $\mu\mu$); that on diminishing the area of such a film there is a formation of microglobules, but it is not possible to say whether the whole of the film is transformed into these; and the thickness of a film in presence of an excess of oil depends on the conditions of its formation, but the method of maximum distension used in order to determine this thickness is lacking in precision. A. D.

1211. *Cunningham's Correction to Stokes' Law.* **I[rene] Parankiewicz.** (Phys. Zeits. 19. pp. 280–281, July 1, 1918.)—Experiments by the author with sulphur and selenium particles furnish what is claimed as a new proof of the validity of Cunningham's correction to Stokes' law of resistance. [See Abs. 188 (1918).] E. H. B.

1212. *Elastic Surface Plane Waves.* **K. Uller.** (Ann. d. Physik, 56. 6. pp. 463–496, Aug. 29, 1918.)—By surface waves are to be understood those which run along the surface of a body and satisfy the surface conditions. Such waves are not free, and have only recently been investigated The present paper deals with elastic waves, of which three types occur in an isotropic body, namely: pure shear waves, pure rarefaction waves, and coupled shear-rarefaction waves. The former types have hitherto been regarded as impossible ; the latter, assumed for simplicity to be plane waves on a plane surface, were first investigated by Rayleigh, who derived an essential cubic equation of condition for the square of the tangential component of the wave normals. The three roots of this equation give three necessary relationships in this wave-pair. Rayleigh's work is discussed at some length. Pure surface shear waves having previously been regarded as impossible, the author examines Wiechert's paper [see Abs. 1048 (1908)] on earthquake waves in this connection. He finds that shear waves must be assumed to explain the experimental data, and opposes Wiechert's conclusion that the earth's crust oscillates as a stratum, himself concluding that seismic waves are without vertical motion, travel with constant velocity and behave as genuine surface shear waves. These bound shear waves are defined by 4 scalars, whereas the free waves demand 8. The paper, which is mathematical throughout, deals at great length with the properties of elastic plane waves, pure surface shear waves, and coupled surface shear-rarefaction plane waves. The absorption of waves in the earth's crust is also discussed. H. H. Ho.

1213. *On the Physical Basis of Einstein's Gravitational Theory.* **F. Kottler.** (Ann. d. Physik, 56. 6. pp. 401–462, Aug. 29, 1918.)—In an endeavour to obtain a physical basis for Einstein's gravitational theory, the author had previously sought (see Abs. 1815 (1916)] for this in the so-called equivalence principle. He now finds this assumption to be in contradiction with experience, and the equivalence hypothesis as derived from Minkowski's kinematics to be inadequate. In the present paper another mode of attack is proposed, namely, a modification of the Newtonian gravitational law as a basis for the Einstein theory. Limitations of two kinds are imposed : (i) The conception of a correct system of reference. This denotes a certain amount of support for Minkowski's postulate of the constant velocity of light in such a way that the determinant of the coefficient of ds^2 in Cartesian coordinates, $g = -c^2$, remains invariant. Only such systems are in agreement with the Newtonian approximation theory in Newtonian coordinates. (ii) Restriction to the stationary character of all gravitational fields. Section I examines the gravitation law considering :—(1) The Newtonian gravitation law. (2) The remaining Newtonian axioms. (3) The variability of light-velocity as a fundamental assumption. (4) The relativity of the new gravitation law. (5) The uniformity of gravitation. (6) The energetics of gravitation. Section II investigates the new assumptions made under the sub-headings of :—(7) The gravitation law according to Minkowski. (8) The generalised refraction law. (9) Calculated systems of reference. The Leith hypothesis. (10) Attraction in consequence of gravity. Section III deals with the field of the mass point at rest under: (11) The basic refraction law and its extremes. (12) The first Newtonian approximation. Kepler's laws. (13) Effects of the second order. The perihelion motion. (14) Numerical values. Section IV considers the general static field under: (15) The Newtonian rigid body and the so-called incoherent mass radiation. (16) The fundamental refraction law and its extremes. (17) Application of the Poisson equation. (18) Introduction of differential invariants. (19) Applications. (20) Derivation of Einstein's equations from the Poisson equation. (21) Determination of the multiplicator from the impulse-energy hypothesis. (22) Discussion of the Einstein equations. Section V investigates the interior of matter under: (23) The external field of the homogeneous static sphere. (24) The field in the interior of the homogeneous sphere. (25) The boundary conditions. (26) Discussion of the selected solution. Some deductions from the theory of matter. (27) Gravity and inert mass. (28) The mass shell. (29) The Leith hypothesis, $g = -c^2$ for Cartesian coordinates. Section VI investigates kinematic singularities of the new gravitation law under: (30) The transformations of ds^2 and the relativity theory. (31) The relativity of acceleration according to Newton in a non-rigid body. (32) The relativity of acceleration according to Minkowski. (33) The same according to Einstein. The equivalence hypothesis. In Section VII the free case and the homogeneous gravitational field are examined under: (34) The free case according to Minkowski. (35) The homogeneous field. (36) Comparison with experience. Section VIII considers uniform rotation and the gravitational turning field under: (37) Uniform rotation according to Minkowski. (38) The gravitational torque. In Section IX the results rendered by the new theory are summarised as follows:—(*a*) An explanation of gravitational uniformity, *i.e.* the facts that all bodies fall with equal speed, the absence of gravitational dispersion, etc. (*b*) The reason why gravitation is purely conservative. (*c*) The Kepler laws as effects of the first order. (*d*) The perihelion motion of Mercury, which is given as an effect of the second order on the same fundamental basis as the variability of mass in the Minkowski mechanics. (*e*) The general Poisson theory of gravitation is found to be an effect of the first order. (*f*) The total mass vanishes for the closed system. (*g*) A limitation is given to the world and its mass. (*h*) In the interior of matter repulsion takes the place of the attraction effect in external space. Hereby is solved the Maxwell problem of stability for an ether theory of gravitation. Further, the impermeability of matter is here characterised. (*i*) Finally, for the theory of the relativity of stationary acceleration, a certain equivalence is given between gravitational field and an accelerated system of reference whereby a relativity postulate is satisfied.

The author trusts that this communication will aid the recognition of the value of the new Einstein theory, by which the gravitation problem has finally been solved. H. H. Ho.

1214. *On the Extension to Physics of the Principles of Homogeneity and Similitude, and on a Remarkable Relation between the Universal Constants of a Theory.* **P. Straneo.** (Comptes Rendus, 167. pp. 360–363, Sept. 2, 1918.)—While the technical applications of the similitude principle have been extended to every domain of Physics in spite of great difficulties attending the practical realisation of similar systems, the theoretical applications of this same principle and of the equivalent one of homogeneity have remained limited to the solitary branch of Mechanics, *i.e.* to where the work of Bertrand had carried them. This is evidently due to the fact that the extension of these principles to

Physics involves the possibility of the entrance in the formulæ of universal constants of unknown dimensions, *e.g.* although there exists a general condition of equilibrium $u = f(T)$ between the density of the energy u of black radiation contained within an enclosure and its temperature T, it has not been possible by the above method to determine the form of the function f because of the inevitable appearance of a universal constant of unknown dimensions. A remarkable attempt to solve this difficulty has been made by Tolman, who by restricting the similitude ratios, *i.e.* by considering as similar only physical systems which possess the dimensional system l, t, m, T and e, found that the one may be deduced from the other by the group of transformations: $l' = xl$, $t' = xt$, $m' = x^{-1}m$, $T' = x^{-1}T$, $e' = e$. Tolman has subsequently shown that a large number of physical laws may be deduced. For instance, the above function treated by this method becomes $u = aT^4$, which is the Stefan-Boltzmann law. Tolman's arguments having raised certain difficulties, the present author now investigates the subject. The limitation introduced in the above transformation is analogous to that employed in Dynamics when only similar systems are considered with invariable parts, in this case the invariable part being the ether. On the other hand the above transformations leave invariable the dimensions of the universal constants, namely, the velocity of light c, the entropy constant k, Planck's constant h, and the dielectric constant ϵ. By bringing together these facts the author has obtained a relation which should subsist between the different universal constants of a theory. In order to avoid any absurd result the author has examined what conditions are necessary between the dimensions of the universal constants, and he concludes that if $[Q_1^{c_1} Q_2^{c_2} \ldots Q_m^{c_m}]$ be the dimensions of a universal constant involved in a theory concerning a system of dimensions $Q_1, Q_2 \ldots, Q_m$, then $c_1, c_2, \ldots, c_m$ should satisfy one or more homogeneous linear equations. Reciprocally the admission of such a relation between the dimensions of the possible universal constants of a theory removes every indeterminate and characterises the theory completely. The author then applies his results to the very extended physical interpretation based upon Newtonian Mechanics, Thermodynamics, and Maxwell's theory of Electricity, of the system l, t, m, T and e. If λ, τ, μ, ϑ, and η be the exponents of the latter dimensions, then the relation $\lambda + \tau - \mu - \vartheta = 0$ is found as a characteristic equation between the universal constants. From such relations all the fundamental laws of gaseous theory, radiation, and electricity may be deduced as consequences of the principles of homogeneity or similitude in their ordinary forms. The theory of radiation is found to be completely characterised by the simple equation: $\lambda + \tau - 2\mu - 2\vartheta = 0$. H. H. Ho.

1215. *Alleged Gravitational Attraction between Revolving Electrons.* **A. C. Crehore.** (Phys. Rev. 12. pp. 18–22, July, 1918.)—The author argues, on the basis of his hypothesis [Abs. 1299 (1917)] of a gravitational attraction between revolving electrons, that the H atom should have two electrons instead of the single electron of Bohr's theory, and on this supposition obtains the same value as that derived from Bohr's theory for the Rydberg constant, representing the max. radiation frequency obtainable for hydrogen. G. W. de T.

1216. *Bohr's Atomic Hypothesis.* **G. A. Schott.** (Phil. Mag. 36. pp. 243–261, Sept., 1918.)—Bohr's latest formulation [Abs. 1437 (1915)] of his fundamental hypothesis is:—" A. An atomic system possesses a number of states in which no emission of energy radiation takes place, even if the particles are in motion, and such an emission is to be expected in ordinary electrodynamics. The states are denoted as the states of stationary motion of the system under consideration." Liénard's well-known expression for the irreversible radiation from an electron is essentially positive, and it vanishes only with the acceleration; and the latter cannot vanish in the case of an electron moving in any way inside an atom. A is therefore necessarily inconsistent with Liénard's expression, which presupposes only the usual expressions for the retarded scalar and vector potential together with the Poynting energy flux. Now the author has shown elsewhere [Electromagnetic Radiation Ch. XI and App. C, D, and F] that the accepted equations of motion of the electron are a direct consequence of the classical equations of the electromagnetic field, Lorentz's and Larmor's expression for the mechanical force on a moving charge, and the definition of force and mass given by Newton's first and second laws of motion. Further, the energy equation derived from these equations of motion defines the kinetic energy of the electron and its radiation without any assumptions as to the proper expressions for the energy densities of the surrounding field and the energy flux. The reaction due to radiation is thus found to consume work irreversibly as well as reversibly, and the rate of the former is as given by Liénard's expression, which is thus shown independently to be consistent with the accepted electron mechanics, and the same holds good for the Poynting flux. The only way to retain A would therefore be if there could be found some modification of the accepted equations of the electromagnetic field which would annul the radiation derived from the Poynting energy flux. To change the Maxwell-Hertz equations for the distant field would apparently involve the loss of the accepted theory of electromagnetic waves. But the retarded potentials depend also on the form of the equations within the electron. A detailed analysis shows definitely, however, that no such modification is possible, allowing of the retention of the accepted electromagnetic equations at a distance from the electron together with the Poynting energy flux, in the case of electrons moving in coaxal circles. In the case of non-circular paths there is generally a tangential as well as a normal acceleration, so there is every reason to suppose that the radiation would be increased, and the author has little doubt that a formal proof could be given, but the already complicated calculations would be much more formidable. The author therefore suggests the modification of Bohr's hypothesis A into a form not open to these objections and which at the same time satisfies the requirements of Bohr's theory in all essential respects:—"A. An atomic system possesses a number of states in which its electromagnetic energy continues unchanged, even if the particles are in motion and an emission of energy radiation is to be expected in ordinary electrodynamics. The states are denoted as the states of stationary motion of the system under consideration." Stress is here laid on the constancy of the electromagnetic energy in spite of radiation, instead of on the total absence of emission of energy radiation. Such emission, as a consequence of radiation, is supposed to occur, not in quanta, but continuously. This need not, however, be inconsistent with Bohr's quantum hypothesis for the series spectrum emission in his hypothesis B. For, whenever emission in quanta occurs, it is now usually attributed to some cause arising from the constitution of the atom rather than that of radiant energy itself. And we have sufficient reason for supposing that the emission of spectrum series is a process of a very special kind, to which the quantum hypothesis may perhaps be applicable, while not holding for the ordinary emission of energy radiation accompanying all accelerated motions of electric charges. G. W. de T.

1217. *Relativity Dynamics of the Electron.* **M. N. Saha.** (Phil. Mag. 36. pp. 76–87, July, 1918.)—The author seeks to formulate, as a basis for mechanics, equations of motion in which mass is replaced by the electric charge of an electron, as the only physical quantity which can be taken as invariable. The fundamental Newtonian equations $md^2x/dt^2 = X$, etc., may be represented by the statement that—The effective force is equivalent to the impressed force. He then assumes as an axiom that this applies to the electron. Impressed force:—Let X, Y, Z, L, M, N, be the electric and magnetic force components at any point, ρ the electron density, v_1, v_2, v_3, the velocity components of the electron; then the components f'_x, f'_y, f'_z, of the impressed force per unit volume at the field-point considered are given by three equations of the type $f'_x = \rho\left\{X + (v_2N - v_3M)c^{-1}\right\}$, where c is the velocity of light. Following Minkowski and writing f_{23}, f_{31}, f_{12} for L, M, N; f_{14}, f_{24}, f_{34} for $-i(X, Y, Z)$; w_1, w_2, w_3, w_4 for $(1 - c^2/v^2)^{-\frac{1}{2}}[v_1/c, v_2/c, v_3/c, i]$; and ρ_0 for $\rho\sqrt{(1 - v^2/c^2)}$; four equations, $f_x = \rho_0[0 + f_{12}w_2 + f_{13}w_3 + f_{14}w_4]$, etc., are obtained for the components of the impressed force at the point-instant (x, y, z, l); and the total impressed force on the electron is then obtainable by integration over the volume of the electron. Supposing the electric and magnetic force constant throughout the volume of the electron, the force components are obtained simply by writing e, the constant charge, for ρ_0.

The determination of the effective force is an answer to the question:—If an electron move with variable velocity, what are the terms corresponding to the quantities md^2x/dt^2, etc., in particle dynamics? To the electromagnetic momentum solution developed by Abraham, Lorentz, and others, the author objects:—(1) That the integration is extended over the observer's space, whereas relativity theory requires its extension over the space perpendicular to the axis of motion of the electron, and external to the volume it occupies: (2) that the volume of integration is taken as bounded by an infinite sphere only, the internal boundary—the surface of the electron—being neglected, remarking that "it looks as if the surface integrals had to go, because the authors wanted to get rid of them." He determines the effective force as follows:—The force components equations may, as shown by Minkowski, be expressed in the form $f_x = \partial X_x/dx + \partial X_y/\partial y + \partial X_z/\partial z + \partial X_l/\partial_l$, etc., where $X_x = 1/8\pi . \left\{f_{23}^2 + f_{34}^2 + f_{42}^2 - f_{12}^2 - f_{13}^2 - f_{14}^2\right\}$, $X_y = 1/4\pi . \left\{f_{13}f_{32} + f_{14}f_{42}\right\}$, etc. According to the relativity theory, the space exterior to the electron, over which f_x, etc., have to be integrated, must be uniquely defined, and is the space perpendicular to the axis of motion of the electron, and is bounded inside by the surface of the electron, with the external boundary at infinity. If $d\Omega$ be an element of this space, the total force is given by $F_x = \int f_x d\Omega = \int\left\{\partial X_x/\partial x' + \partial X_y/\partial y' + \partial X_z/\partial z' + \partial X_l/\partial l'\right\} d\Omega$, at an external point-instant $(x', y' z', l')$. But the vector potential, and therefore the functions f_{12}, etc., are functions of the relative distance between this and (x, y, z, l), so that $\partial X_x/\partial x' = -\partial X_x/\partial x$, and thus—

$$F_x = -\left\{\partial/\partial x\int X_x d\Omega + \partial/\partial y\int X_y d\Omega + \partial/\partial z\int X_z d\Omega + \partial/\partial l\int X_l d\Omega\right\}.$$

These integrals are obtained very simply by aid of a Lorentz transformation by which the axis of motion becomes the new time axis, and the inner surface of the electron being taken as a sphere of radius a, it is shown that the X component of the force on the external space $= -2e^2/3a . d^2X/ds^2$. This force may be interpreted as the reaction of the electron on the external space, so that the effective force on the electron, equal and opposite to this, will have the four components $2e^2/3a\,.\,d^2x/ds^2$, etc. For small velocities $ds = cdl$ approximately, so that the quantity $2e^2/3ac^2$ may be taken as the rest-mass of the electron, and the equivalent of m_0, which agrees with the result obtained by J. J. Thomson, Lorentz, and Einstein, for slow-moving electrons. The author points out that none of the quantities $\int X_x d\Omega$, etc., vanish, as they do in other theories. The effective force or an electron, instead of being simply the rate of change of momentum, becomes the sum total of the time rate of change of the quantity $\int \partial X_x/\partial l\,.\,d\Omega$ + the space rates of change of the quantities $\int \partial X_x/\partial x\,.\,d\Omega$, etc. The latter quantities involve velocity in the second order, whereas the former involve velocity in the first order, so that when the velocity is small compared with that of light, the result approximates to Newton's second law of motion. G. W. DE T.

1218. *Free Air Data at Drexel Aerological Station, January to June,* 1917. **W. R. Gregg.** (Monthly Weather Rev. Supplement No. 10. pp. 5–101, 1918.)—In the six months 249 observations were made with kites, reaching a mean height of almost 3000 m. Two ascents on noteworthy occasions are discussed. In the first an unusually large deposit of rime was formed upon the kites and on that portion of the wire which lay in the cloud layer. The coating on the wire varied in thickness from 1¼ to 8 mm. On the second occasion the kites and 4000 m. of wire were caught in a thunderstorm and struck by lightning. The meteorograph record showed that there were two cloud layers separated by 1100 m. of dry air, in which the temperature gradient was almost adiabatic. The flash appears to have originated in the upper cloud layer and travelled down to the winch. The wire in the relatively dry air between the two cloud sheets was destroyed, while that portion within the lower cloud was undamaged. This result was evidently due to the layer of moisture collected. The wire, of larger section, below the lowest cloud sheet was injured, being turned a brown or blue colour. During the six months nine series of observations on the diurnal changes in the upper air were carried out. The data obtained are set out in tables and also in figures. J. S. Di.

1219. *Influence of Radius of Curvature of a Body on the Formation of Hoar Frost.* **G. Reboul.** (Comptes Rendus, 167. pp. 331–333, Aug. 26, 1918.)—In order to determine the effect of radius of curvature on the rate of deposition of hoar frost six rods of diams. ranging from 0·5 mm. to 8 mm. were exposed on Feb. 1, 1918, for a period of 20 hours. At first the hoar frost formed most rapidly upon the smaller rods, and after three hours it had attained a depth of 4 mm. on the smallest rod and only 0·5 mm. on the rod 4 mm. in diameter. Later the rate of deposit became equal on all the rods. This is explained by the fact that when once a deposit has formed further deposition occurs on the existing crystals and the form of the underlying body becomes unimportant. J. S. Di.

1220. *Solar Disturbances and Terrestrial Weather.* **E. Huntington.** (Monthly Weather Rev. 46. pp. 123–141, March; 168–177, April, and pp. 269–277, June, 1918.)—Sun-spots, faculæ, and the solar constant are considered and an attempt made to ascertain their connection with the steepness of the barometric gradient over the North Atlantic and neighbouring land areas. As an approximate measure of the steepness of gradient the number of intersections of isobars with the degree net formed by every fifth meridian of longitude and every fifth parallel of latitude is used. This method suffers from certain imperfections which are discussed. The data accumulated have been worked up in many different ways and the results are set out in numerous tables and diagrams. The chief conclusion is as follows:—The greatest changes in barometric gradient from one day to the next over the North Atlantic occur on occasions when the "Quadrant difference" of sun-spots is at a maximum, that is, when the total spotted area in the outer parts of one pair of opposite quadrants of the solar disc differs most widely from the spotted area in the outer parts of the other pair. Another conclusion of interest is that when sun-spots are numerous their effect on terrestrial conditions is felt with less time-lag than when they are few in number. It is also found that spots near the centre of the solar disc have very little effect compared with spots near the margin.

Faculæ, unlike sun-spots, have but little influence on barometric gradients. As regards changes in the solar constant it is found that after days of strong solar radiation there is a steady increase in the variability of the gradient, or percentage change from one day to the next, which continues for 8 or 9 days. J. S. Di.

1221. *On the Cooling of Air near the Ground at Night.* **G. Hellmann.** (Preuss. Akad. Wiss. Berlin, Ber. 38. pp. 806–813, 1918.)—From observations of 10 minimum thermometers, which were arranged at every 5 cm. interval of height above the ground from 5 to 50 cm., the variation of minimum temperature with height is investigated. On clear nights a regular increase of temperature with height is shown, which follows an exponential law. On the average the difference of temperature from the ground to 50 cm. height is 8·7° C. An increase of cloudiness by one degree of the usual scale (0 = clear, 10 = overcast) diminishes this difference by a full third of a degree Centigrade. An overcast sky gives no difference of temperature; rainy and windy weather gives a diminution of temperature of a few tenths of a degree. R. C.

1222. *The General Movements of the Atmosphere.* **P. Garrigou-Lagrange.** (Comptes Rendus, 167. pp. 170–172, July 22, 1918.)—In order to follow with ease the movements of the atmosphere over large areas from day to day, a series of synoptic weather charts is arranged in sequence of time on a kinematographic film, so that the charts can be rapidly passed in review. Three such films have been prepared, two for Europe and North Asia, and one for North America. R. C.

1223. *The "Warmth of Dawn."* **O. Meissner.** (Phys. Zeits. 19. pp. 387–388, Sept. 1, 1918.)—From hourly readings of temperature as recorded at the Potsdam Observatory, the conclusion is reached that the difference in point of time between temperature-minimum and sunrise has a definite seasonal variation both for clear nights only, and on the average of all nights. From May to September the time of minimum temperature occurs 30 mins. after sunrise; in spring and autumn the interval is reduced to 15 mins., but in winter minimum temperature occurs 10 minutes earlier than sunrise. Thus there is nothing in the observations to support the "warmth of dawn" theory. R. C.

1224. *Evolution of Solar System.* **H. Jeffreys.** (Nature, 101. pp. 447–449, Aug. 8, 1918.)—This paper is mainly a summary of conclusions arrived at by J. H. Jeans and by the author [Abs. 364 (1917) and 474 (1918)]. He considers that at every point where the tidal hypothesis has been tested it agrees

with dynamical theory and with observation; that several facts otherwise unaccounted for are explained by it; and that nothing has yet been discovered to be definitely opposed to it, although a few difficulties, such as the origin of comets and meteor swarms, still remain. Among several possible explanations of the origin of the asteroids, he suggests as the most probable the close approach of a primitive planet to Jupiter, leading to tidal disruption.
G. W. DE T.

1225. *Accumulated Energy from Contraction of the Sun.* **Auric.** (Comptes Rendus, 167. pp. 328–329, Aug. 26, 1918.)—Poincaré in repeating Helmholtz's calculations for the mass and energy of the sun, assuming the density to vary inversely as some power (α) of the radius, finds an expression giving an infinite mass for the value $\alpha = 3$ (inverse cube). The present paper points out that the expression for the energy becomes infinite when $\alpha = 2\frac{1}{2}$, so that abundant energy becomes available for certain hypotheses which were supposed untenable.
W. W. B.

1226. *Radial Velocities of the Stars ϵ and γ Orionis.* **F. Henroteau.** (Lick Observat., Bull. 9. [Circ. No. 314] pp. 178–180, 1918.)—ϵ Orionis yields a poor spectrum, and previous observers have failed to find a period of variable velocity. From his own and Neubauer's recent observations, the author concludes the star is not a short-period binary. γ Orionis may be a binary, but the determination of its orbit would be very difficult owing to the small range of radial velocities.
H. F. H.

1227. *Spectrographic Study of σ Scorpii.* **F. Henroteau.** (Lick Observat., Bull. 9. [Circ. No. 314] pp. 173–178, 1918.)—σ Scorpii is a short-period binary of spectral class B 1. From his own 3-prism spectrogram measures of 1918, and from Selga's 1-prism measures of 1915, the author obtains 17 nearly complete velocity curves, of constant amplitudes, although the velocity of the centre of mass is variable. The different velocity curves are connected by a well-determined period, and may be superposed so that they have the same undetermined mean velocity. Figures are given for the elements of the short-period orbit. By superposing the mean velocity curve with its centre-of-mass velocity line on each velocity curve, values of the centre-of-mass velocity are obtained, giving a period of 34·08 days, and the orbit of the centre is an ellipse. From the change in line widths in the spectrum the author deduces that the max. line width occurs near periastron, and the minimum near apastron. This result supports the hypothesis that the variation of amplitude in the velocity curve of β Canis Majoris is due to the combination of two motions. [See also Abs. 1054 (1918)].
H. F. H.

1228. *Orbit of the Binary Star A* 417 = 83 *Aquarii.* **R. G. Aitken.** (Lick Observat. Bull. 9. [Circ. No. 317] pp. 191–192, 1918.)—This star had been noted in 1902 as a close pair with components of equal brightness, its proper motion being given as 0·123″ in 82°. The author gives his measures since 1902 of this pair over 270° as the basis for the computation of a preliminary orbit; he also gives the resulting elements as worked out from the annual means for 1914–1918. Assuming the mass of the system twice that of the sun, the elements give 0·023″ for the parallax, which is in harmony with the magnitude 5·56, spectral class A, and proper motion of the star.
H. F. H.

1229. *Parallaxes and Motions of the Brighter Galactic Helium Stars between Galactic Longitudes* 150° *and* 216°. **J. C. Kapteyn.** (Mt. Wilson Solar

Observat. Contrib. No. 147. Astrophys. J. 47. pp. 104–133, March; 146–178, April, and pp. 255–282, May, 1918.)—This paper aims at deriving individual parallaxes and motions of helium stars between galactic latitudes ± 30° and above longitudes, those between 216° and 360° having already been dealt with [Abs. 40 (1915)]. For material, the author has used all the 168 B stars in Boss's catalogue, and hundreds of B and A stars, some fainter than 9·5, for which Miss Cannon has recently determined the spectra. The bulk of the B stars within the area R.A. 5 h. 13 m. and 5 h. 40 m., Dec. −9° and + 5° (which includes the Orion nebula) form a local group, called the "Nebula-group" by the author. Necessary corrections for Boss's proper motions in declination are dealt with; and definitive elements of the motions of helium stars outside the nebula region are given; their average parallax is 0·0081″ ± 0·0007″, that of the nebula-group being 0·0054″ ± 0·0009″. Various tests have been applied to these parallaxes, in general strongly confirmatory. The smallness of the components of the linear peculiar motion of these stars is regarded as one of the most important points brought out. Luminosity curves have been determined for many subdivisions of B stars, and a summary of the results is tabulated. The direction and velocity of the nebula-group stars appear identical with outside stars. H. F. H.

1230. *Nova Aquilæ.* **G. F. Paddock, W. S. Adams,** and **A. H. Joy.** (Astron. Soc. Pacific, Pub. 30. No. 176. Nature, 102. p. 74, Sept. 26, 1918. Abstract.)—Preliminary accounts from the Lick and Mt. Wilson observatories. G. F. Paddock at Lick Observatory refers to the extraordinary changes in position and intensity in a pair of absorption lines at λ4058 and 4064, and notes that the green nebular line appeared on June 23. He also gives a list of bands on a plate taken June 21, including seven lines in the red and yellow. The Mt. Wilson observers note a displacement of broad, heavy bands of hydrogen, about 20 Å. towards the violet. W. W. B.

1231. *Nova Aquilæ Spectrum.* **J. S. Plaskett.** (Roy. Astron. Soc., Canada, J. 12. pp. 350–356, Sept., 1918.)—Of 60 spectrograms of the nova secured with a single-prism spectrograph at the new Dominion Astrophysical Observatory, a selection of eleven is reproduced in a plate accompanying the original article, showing the important changes in character from June 10 to Aug. 5. The measurable region extends from H_β into the ultra-violet, 19 consecutive hydrogen lines being measured and 3 more seen on June 19. Notes are given of the varying appearance and intensity of absorption bands of hydrogen and calcium and enhanced metallic lines. Sixty-five metallic lines measured on the plates from June 10 to 15 are chiefly due to Ti, Fe, Cr, Sr, Sc, and V. These are displaced in proportion to wave-length, but the cause is considered to be probably not the high velocity indicated, especially as the hydrogen absorption indicates two different velocities. Special attention is given to the calcium H and K lines, which do not appear to belong to one body. Preliminary measures are given of the wave-lengths of some of the nova and nebular bands. W. W. B.

1232. *Star-counts on Harvard Map.* **H. Nort.** (Recherches Astron. de l'Observat. d'Utrecht, No. 7. Observatory, No. 529. pp. 328–330, Aug., 1918. Abstract.)—Stars down to 11th magnitude were counted on more than 5000 fields, about 100 on each of the 55 plates of the Harvard map. This was done by H. Henie at Lund; and the present paper is an attempt to standardise his results. The average star density varies with galactic latitude from 10·2 per square degree at the galactic pole to 47·8 on the galactic plane, but there is a discontinuity at the edge of the galaxy, and the author's formula, density = 14·6 + 31·0 $\cos^{10}$(galactic latitude) is therefore not a good fit. Analysis with galactic longitude shows some conspicuous irregularities, but no marked want of symmetry on the whole. The author also concludes (with Pannekoek) that there is no organic connection between the great mass of the stars to the 9th or perhaps the 11th magnitude and the star clouds of the Milky Way. W. W. B.

1233. *Distances of Orion Nebula, Pleiades, and Coma Berenices.* **W. H. Pickering.** (Harvard Obs. Circ. Nos. 205, 206. Observatory, No. 530. p. 361, Sept., 1918. Abstract.)—From a study of the blue stars the author obtains a distance for the Orion nebula of 2000 parsecs (about 6600 light-years), and a diameter of 1700 light-years. Rigel appears to be more than two million times as bright as the sun. The mean distance of the Pleiades comes out at nearly 700 light-years with a diameter for the group of 70 light-years, Alcyone being more than 2000 times as bright as the sun. The Coma Berenices cluster has a diameter of 25 light-years and a distance of 301 light-years. W. W. B.

1234. *Scales for Star Colours.* **T. W. Backhouse.** (Observatory, No. 528. pp. 288-291, July, 1918.)—After briefly discussing various systems of colour scales, including the modern methods by colour-index, or by effective wave-length, the author describes his own modification of a scale of redness or want of redness, and gives a table of about forty stars arranged in order of redness with a comparison between his notation and those of Krüger and Franks, and with a few effective wave-lengths. There are indications of a considerable colour equation for different observers. W. W. B.

1235. *Orbit of Sirius.* **R. G. Aitken.** (Lick Observat. Bull. 9. [Circ. No. 316] pp. 184-190, 1918.)—This binary having now completed more than a revolution, a complete discussion of the visual observations up to Jan. of the present year is given with certain corrections. The revised period is almost exactly 50 years, and the author's ephemeris predicts periastron in 1944. He discusses indications of personal equation in certain of the measures; and also radial velocity determinations, from Potsdam, Cape, and Lick Observatories, in particular, concluding that the evidence as to a secondary motion is unconvincing and that simple elliptic motion is probable. W. W. B.

1236. *Changes of Wave-length with Change of Type in Stellar Spectra.* **F. E. Baxandall.** (Astrophys. J. 48. pp. 59-61, July, 1918.)—The author discusses Voûte's recent results [Abs. 755 (1918)] in a research formerly initiated by Albrecht on the progressive changes of wave-length of stellar lines, depending on the spectral type. He points out several discordances between the results of Albrecht and Voûte, and deals with numerous cases in which what has been given as change may be more probably attributed to blending. Evidently more research is wanted in this direction, Albrecht's promised continuation not yet having appeared. W. W. B.

1237. *Stellar Evolution.* **W. D. MacMillan.** (Astron. J. 48. pp. 35-49, July, 1918.)—Starting with the two questions: "What becomes of the enormous flood of energy which is poured forth so lavishly by the sun and by the stars?" and "What is the source of the enormous sub-atomic energies which have been revealed in recent years by the radio-active elements, and which by implication exist in all of the other elements?" the author sees no alternative but to assume that the questions answer each other, and proceeds to consider the possible processes by which radiant energy is transformed into the sub-atomic energies of the atoms. Space, he feels, cannot be finite, but if infinite then there must be extinction of radiant energy to some extent in its passage through space. The brightest star in absolute magnitude (Canopus) is 2¼ million times as bright as the faintest known star—a range of sixteen magnitudes. Uniform distribution seems to agree quite well with the actual star-counts of Chapman and Melotte, on the hypothesis that 1 % of light is extinguished in travelling 18·6 light-years; for which the author finds the presence of one grain of cosmic dust of 0·01 in. diam. in every 560 cubic miles will suffice. But this does not explain the life-history of the interrupted radiation, and the author goes on to suggest a model system of sub-atoms which have a capacity for joining up under the influence of external energy, and on the hypothesis that atoms are built up in some such manner, traces the order of evolution of the members of the solar system, from solid to gaseous, stellar and, ultimately, nebular. The process indicates a probable maximum of stellar mass beyond which a star must become a nebula, which would account for the rather small range in known masses. The "giant" and "dwarf" red stars also fit into the scheme, as two processes are recognised for the "birth" of a star, namely, condensation from a nebula, and growth from a nucleus, the latter being more usual apparently. No upper limit can be assigned to the life of a star, nor any limit to the number of lives. Near approaches and collisions are considered; and the author applies his suggested process to the future condition of the solar system, which, he thinks, may tend to become a binary, Jupiter growing faster than the sun, while the latter may even be losing mass, until the two masses become nearly equal. His actual computation of the effect of a fivefold increase in mass is that the distance of Jupiter would be reduced from 500 million miles to 4 million miles and its period from 12 years to 38 hours.

An extension of the planetesimal hypothesis will account for many binary stars, both visual and spectroscopic, and also for novæ. No star can go out of existence except by collision or by very close approach, resulting in the union of two masses in the former case, or disruption in the latter. But the fluctuations in the stars are inappreciable in the universe as a whole, which latter, the author thinks, need never have been in the past or become in the future essentially different from what it is to-day. W. W. B.

1238. *Distances of Globular Clusters.* **H. Shapley.** (Mt. Wilson Solar Observat. Contrib. No. 151. Astrophys. J. 48. pp. 89–124, Sept., 1918.)—In continuation of previous investigations [Abs. 650 and 651 (1918)] into the dimensions of globular clusters and their structural connection with the galaxy, the present paper deals more directly with their distances and distribution in space. The method employed is naturally indirect, as direct measurement of cluster parallaxes is out of the question, and recourse is had to the bright Cepheid variables in the clusters, and particularly to the giant stars of longer period.

Starting with a general treatment of extensive data bearing on the magnitudes, periods, light-curves, proper motions, and radial velocities of Cepheid variables in the galaxy and other systems and on the angular diameters of clusters and the number, magnitudes and colours of their individual stars, an idea is gained of the extent and arrangement of the galactic system and the sun's position therein. The next step is to derive from their parallactic motions the mean absolute magnitudes of eleven isolated Cepheid variables, namely: Polaris, S U Cassiopeiæ, R T Aurigæ, ζ Geminorum, X Sagittarii, W Sagittarii, Y Sagittarii, η Aquilæ, S Sagittæ, T Vulpeculæ and δ Cephei. The probable error of these appears to be relatively small, and the luminosities are shown to be dependent on their periods. An extension of these results gives a relation connecting the periods of both the ordinary Cepheids and the cluster-type variables with their absolute magnitudes, which permits the derivation of the distances of all such variable stars from their periods and apparent magnitudes: and also yields the parallax of any cluster containing Cepheid variables, on the hypothesis that Cepheids of a given period are always comparable. Data for more than 200 individual variables from seven different stellar systems are used, to determine the correlation between luminosity and period, and it is said that Cepheid variables are not found fainter than a definite standard.

The next section substitutes apparent magnitudes of the brightest stars in the cluster instead of the variables to determine the distance.

The final stage in the present paper consists of an extension to include all globular clusters, whether they include Cepheids or not, by correlating the angular diam. of each cluster with the known distances. The statistical results are postponed to the next paper of the series. W. W. B.

1239. *Magnitudes in Star-clusters.* VIII. *Summary in Relation to Structure of the Universe.* **H. Shapley.** (Nat. Acad. Sci., Proc. 4. pp. 224–229, Aug., 1918.)—Extending to globular clusters the work of Miss Leavitt, Hertzsprung and Russell on the Cepheid variables of the small Magellanic cloud and of the galaxy, the author claims to have established unmistakable correlation between absolute luminosity and light-period. Globular clusters being much further off than even Cepheid variables, which are very distant compared with ordinary naked-eye stars, only 69 appear to be known within 100,000 light-years of the sun; very few being within 5° of the galactic plane. They nevertheless, the author considers, do belong to the galactic system, the whole having a diameter of at least 300,000 light-years, with the solar system eccentrically situated in it. Most of the globular clusters in high galactic latitudes appear to be rapidly approaching the sun, and those in lower latitudes are less condensed; so the author suggests that globular clusters may be disrupted on approaching the galactic regions.

To test further Charlier's hypothesis of a limited local cluster comprising the B stars, the galactic arrangement of the brighter stars is investigated. The local cluster then appears to contain nearly all the B stars brighter than seventh magnitude, most of the A stars, and many of the redder types: its central plane not more than 30 light-years south of the sun, the true galactic plane being about 175 light-years to the south of the local cluster, which also is inclined about 12° to the galactic plane and has a diam. about the order of 2500 light-years. The author therefore interprets star-streaming as the motion of an open cluster (Stream I) through the general galactic field (Stream II). W. W. B.

LIGHT.

1240. *Prism Binoculars for detecting Diplopia.* **A. Blondel.** (Comptes Rendus, 167. pp. 226–227, Aug. 5, 1918.)—In a subject suffering from affections of the nervous centres, it is found that with direct vision the images on the two retinas are correctly superposed even in the fatigued condition, while in the case of vision through prism binoculars a double image is seen. This phenomenon disappears after a period of rest. The cause cannot be entirely attributed to the increased angle between the rays from the object to the two eyes, but it may be due either (1) to a general lack of accommodation due to the extra fatigue imposed by the strain of accommodating the extra angle for a considerable time, or (2) to a lack of centring of the crystalline lenses with respect to the eyepieces of the binoculars. It is suggested that use may be made of this phenomenon for the detection of defects in the nervous centres, by causing double vision to appear more readily. J. W. T. W.

1241. *Reflecting Surfaces with Negative Curvature.* **P. Selényi.** (Phys. Zeits. 19. pp. 386–387, Sept. 1, 1918.)—A continuation of previous work [Abs. 663 (1918)]. Particular attention is paid to a peculiar stereoscopic effect observed with the special mirrors dealt with. A. W.

1242. *Mirage on the Queensferry Road.* **A. G. Ramage.** (Roy. Soc. Edinburgh, Proc. 38. 2. pp. 166–168, 1917–1918.)—At a certain spot the author so regularly saw mirage effects that he is tempted to call them a "permanent" phenomenon and detail observations were possible. The appearance took the form of pools of water reflecting grass and foliage very clearly. A horse passing beyond the spot appeared to be about twice its natural height. On one cool to cold day with occasional gleams of sunshine the form was of a silvery band across the road. The road surface is bituminous and contains small particles of quartz. It was demonstrated that some of these particles were being carried up by convection currents on days when the mirage was visible and the suggestion is made that the particles gave rise to the phenomenon.

J. S. Di.

1243. *The Minimum Energy Necessary to Produce the Sensation of Light.* **H. Buisson.** (Journ. de Physique, 7. pp. 68–74, March–April, 1917.)—The author recalls the results obtained by other observers. Langley for $\lambda = 5500\mu\mu$ found 28×10^{-10} erg-sec. and Drude 60×10^{-10} erg-sec., but the latter's assumptions regarding the pupil-aperture and the mechanical equivalent of light were probably incorrect. Ives has found 38×10^{-10}, Russell $7{\cdot}7 \times 10^{-10}$ and Reeves $19{\cdot}5 \times 10^{-10}$ erg-sec. The author describes some recent experiments conducted with the Fabry-Buisson microphotometer by which an image of a phosphorescent source of light is projected on to the pupil by a lens. He thus arrives at a value of $12{\cdot}6 \times 10^{-10}$ erg-sec., which is intermediate between the values observed respectively by Reeves and Russell. The value of this quantity naturally depends on the sensitiveness of the eye of the observer. J. S. D.

1244. *Effect of Size of Stimulus and Exposure-time on Retinal Threshold.* **P. Reeves.** (Eastman Kodak Co.'s Research Lab., Comm. No. 68. Astrophys. J. 47. pp. 141–145, April, 1918.)—Previous determinations of the minimum radiation visible as light have been made by the observer and others [Abs. 667, 668 (1918)]. For the author's eye a value of $17{\cdot}1 \times 10^{-10}$ erg per sec., for three observers (mean) $19{\cdot}5 \times 10^{-10}$ erg per sec. was found. In these experiments a star 1 mm. in diam. at a distance of 8 m., thus resembling a distant point of light, was used. In the experiments now described the area of the source and the time of exposure were varied within wide limits. The experimental apparatus is described and the results are assembled in tabular form. The author employs the expression: "Least perceptible radiation" $= \mathrm{SLM}\,\frac{n^2}{\mathrm{R}^2}$ ergs per sec., where S is the area of the stimulus in cm.^{2}; L the brightness of the stimulus in lamberts; M the mechanical equivalent of light (given by Ives as 1·59 ergs per sec. per cm.^{2}); n the radius of the pupil and R the distance of the eye from the stimulus. With a 1-mm. star at 8 m., 1·5 m., and 35 cm., values of $17{\cdot}1 \times 10^{-10}$, $24{\cdot}8 \times 10^{-10}$, and $42{\cdot}1 \times 10^{-10}$ erg per sec. were recorded. With a distance of 35 cm. and stars from 2 mm.^{2} to 12 cm.^{2} very wide variations, namely, from $25{\cdot}3 \times 10^{-10}$ to 564×10^{-10} erg per sec., were noted. Similarly with a 3-cm.^{2} source at a distance of 35 cm. and a range of exposures from 0·002 to 4 secs. the reciprocal of the threshold varies from 2·76 to 1588. The sensibility increases rapidly up to 2 secs., after which the increase is much less, while exposures of 8, 12, and 20 secs. almost invariably show a decrease of retinal sensibility. J. S. D.

1245. *The Law of Symmetry of the Visibility Function.* **I. G. Priest.** (Phys. Rev. 11. pp. 498–502, June, 1918. Abstract of paper read before the Am. Phys. Soc., April, 1918.)—It is remarked that if the relative visibility of a radiant power is plotted as ordinate against the wave-length as abscissa the resulting curve is approximately symmetrical about the maximum ordinate. The author presents the curve, the ordinate being relative visibility and the abscissa representing frequency of vibrations. Various corrections are discussed and reference is made to inevitable uncertainties in the extreme regions of the spectrum. The average retinal visibility is found to be almost exactly represented by the relation: $\mathrm{V} = e^{-0{\cdot}0002664(f-541)^2}$; where f is frequency in vibrations per 10^{-12} second, and V the ratio of visibility at frequency f to the max. visibility at frequency $= 541$. J. S. D.

1246. *Production of Artificial Daylight.* **I. G. Priest.** (Phys. Rev. 11. pp. 502–504, June, 1918. Paper read before the Am. Phys. Soc., April, 1918.)—Light having a spectral distribution closely resembling that of daylight may be produced by passing the light from an artificial source, such as an acetylene flame, vacuum or gas-filled tungsten lamp, through two Nicol prisms with a crystalline quartz plate between them, the thickness of quartz and angle between the principal planes of the nicols being suitably chosen. A still closer approximation can be secured by using three nicols, a quartz plate being placed between the first and second and also between the second and third. The exactitude of the method is verified by reference to the black body at 5000 abs., sunlight at the earth's surface and sunlight outside the atmosphere; the constants to secure accurate resemblance to the light being given in each case. Spectrum distribution curves for these three forms of radiation are also presented. The advantages claimed for the method are: (1) accuracy, (2) reproduceability, and (3) adjustability. The method is not regarded as competing with industrial methods of producing artificial daylight by suitable filters, but has advantages when great accuracy is needed and it is only required to illuminate a small area. In particular the method avoids the distortion arising from a sharp maximum at $\lambda = 570\,\mu\mu$ which is characteristic of screening methods. J. S. D.

1247. *Light-pressure.* **O. Klotz.** (Roy. Astron. Soc., Canada J. 12. pp. 357–362, Sept., 1918.)—According to the electromagnetic theory of light, radiation falling upon a body exerts a pressure on it, as was shown experimentally by Lebedev. Further, the pressure is proportional to the radiation, and is inversely proportional to the square of the distance from the source of radiant energy. Thus the light-pressure at the surface of the sun is about 46,000 times that when the radiation reaches the earth, as the distance to the earth is about 216 times the radius of the sun, the pressure behaving as if the radiation emanated from the centre of the sun.

Consider a black spherical particle at the surface of the sun, subject to solar gravitation and to light-pressure acting oppositely. Suppose gravitation is n-times the light-pressure. Now let the radius of the particle be halved; the result will be that the pressure force becomes one-quarter, since it depends on the area, while the gravitational force becomes one-eighth, since it depends on the mass and volume. Thus the ratio n has been decreased to $n/2$. And so we can go on reducing the dimensions of our particle until n is less than unity, that is, until the light-pressure effect exceeds the gravitational effect, and the particle is pushed away from the sun into space against solar gravity. It is shown that for a diameter of $1{\cdot}6\,\mu$, or 2·7 times the wave-length of the D line, the solar radiation-pressure and gravitation are balanced. E. H. B.

1248. *A New Solution and Extension of Sommerfeld's Diffraction Problem.* **R. Hargreaves.** (Phil. Mag. 36. pp. 191–199, Aug., 1918.)—The two-dimensional problem solved by Sommerfeld was the first diffraction problem to which exact methods have been successfully applied. The author gives a simpler and more convenient solution, and extends it to three dimensions by obtaining a solution where the plane of the incident wave is no longer parallel to the edge of the barrier. The solution is first obtained as a definite integral which is directly expressible in terms of Bessel's functions and circular functions. He also shows that when the latter form is arrived at directly, the crux of the problem lies in the asymptotic value of the series.

G. W. de T.

1249. *On Crystals possessing Optical Activity.* **T. Liebisch.** (Preuss. Akad. Wiss. Berlin, Ber. 38. pp. 821–839, 1918.)—The propagation and polarisation of plane waves of monochromatic light in a transparent active anisotropic crystal may be regarded as the result of interaction between an ordinary double refraction with waves polarised at right angles to each other and a double refraction with circular polarisation. For investigating active biaxial crystals, whose optic axes are only slightly inclined, a suitable polariser and analyser must be chosen, and these are exhaustively described with 3 diagrams in Section I of the paper. The interference figures thereby produced, using convergent sodium light, are explained in detail for various types of crystal in the remaining sections. Doubt is expressed with regard to Vorländer and Huth's statement that all inactive liquid crystal phases possess positive double-refraction, since all hitherto investigated liquid crystal phases which are pleochroic, surface coloured, and circularly polarised show a negative character. Although the above authors have described interference figures in support of their theory, yet they have failed to give the arrangement of their polarisation apparatus, which may have introduced the explanatory errors. The use of quartz plates of varying thicknesses in the experiments is described in detail, these having proved invaluable. The case of cane sugar is given, this being an example of an active biaxial crystal possessing negative double-refraction and opposite rotative powers of unequal strengths in the directions of the optic axes. Three plates are included, each containing 6 interference figures obtained under varying experimental conditions. H. H. Ho.

1250. *The "Astronomical Atom" and the Spectral Series of Hydrogen.* **F. Sanford.** (Astron. J. 48. pp. 1-12, July, 1918.)—Assuming that radiating electrons are revolving in elliptical or circular orbits about a central positive charge with velocities such that the photoelectric equation $\frac{1}{2}mv^2 = h\nu$ applies to them, the author has previously shown that their orbital radii may be computed, and that these bear a linear relation to the corresponding atomic radii computed from other considerations [Abs. 220 (1917)]. Further, it has been shown that on the same assumptions regarding the electrons which emit X-rays it is possible to compute the nuclear charges of the radiating atoms by means of Moseley's equations for X-ray frequency, and that these charges are, as suggested by van den Broek, simple multiples of the unit electrical charge [Abs. 788 (1917)]. The purpose of the present paper is to discuss the spectral series of hydrogen on the same hypothesis. Upon the hypothesis of a planetary orbit for each radiating electron it is shown that its effective charge may be computed from the equation $Q = 2{\cdot}882 \times 10^{-12}/\sqrt{\lambda}$. Using the Balmer equation in the form $1/\lambda = 1/h\,\{(m^2 - 4)/m^2\}$, it should then be possible to calculate Q from this equation by writing $Q = A\sqrt{[(m^2 - 4)/m^2]}$. In this equation A becomes a fundamental atomic charge from which all the other charges are computed. Calculations for the first nine lines of the Balmer series and for the line for which $m = 31$ are given, and show a remarkable constancy for the value of A, the mean value obtained being $e = 4{\cdot}778 \times 10^{-10}$ e.s. unit. From this result it follows that the Rydberg frequency N is the frequency which would be given by an electron revolving about a positive charge $2e$. Similar calculation for the lines of the Pickering series gives a mean value for e of $4{\cdot}772 \times 10^{-10}$ e.s. unit, and the lines of the principal series give the value $4{\cdot}777 \times 10^{-10}$. As regards the lines predicted by Ritz and observed by Lyman in the far ultra-violet it appears that this series may belong to helium. The principal series of hydrogen converges to a positive charge greater than e, and since there is apparently no way of increasing the charge of a hydrogen atom except by abstracting an electron, it would seem possible to have a hydrogen atom with a nuclear charge of $2e$. Such an atom should give off radiation of higher frequency than one with a charge e, and its spectrum should lie in the ultra-violet. The fact that the hydrogen atom may apparently exist in two electrical conditions in one of which the central charge is e and in the other $2e$, raises the question as to which corresponds to the normal or so-called neutral condition of the atom. If the normal charge is e, the charge $2e$ must be caused by the abstraction of an electron from the normal atom, and the radiating system which gives rise to the principal series and the Ritz-Lyman series must be electro-positive. If, on the other hand, the normal atom has a central charge of $2e$, it would seem that the Balmer series and the Pickering series must be due to atoms which have captured an electron and have thus become electro-negative. It is interesting to note that Strutt found that luminous hydrogen atoms which gave the Balmer series were universally electro-negative. There is so far no

experimental evidence that either hydrogen or helium may give rise to X-rays. The Moseley equation for *k*-radiation would give for hydrogen $Q = 2e(1 - b)$ and for helium $Q = 2e(2 - b)$. If we accept Moseley's value of $b = 1$ for the *k*-radiation, λ_k for helium $= 912$, and the Ritz-Lyman series in hydrogen and helium starts with the convergence wave-length of the X-ray spectrum of helium.
A. W.

1251. *Stark-effect.* VII. **J. Stark, O. Hardtke,** and **G. Liebert.** (Ann. d. Physik, 56. 8. pp. 569–576, Sept. 20, 1918.)—This paper deals particularly with Fowler's helium series. Measurements have been made with various fields for the lines λ2733 and λ3203, and the results of Nyquist for the line λ4686 are included for comparison, the displacements for a field of 100,000 volts per cm. being obtained by extrapolation. A diagram shows that the effects for the first members of the Balmer series of hydrogen, λλ4341, 4861, and 6563, are similar in every respect to the effects observed with the He lines λλ2733, 3203 and 4686. [See Abs. 660 (1914).]
A. W.

1252. *New Principal Series of Helium.* VIII. **J. Stark.** (Ann. d. Physik, 56. 8. pp. 577–588, Sept. 20, 1918.)—In the course of investigations of the Stark-effect for helium lines two new series of lines have been discovered. The first of these is a diffuse principal series and has a formula $\nu = Ez(h) - Lz(m, d)$. The calculated wave-lengths agree remarkably with the observed values for the second to the sixth members of the series. The first member, λ3810·3, was not observed with certainty, as it lies near the four components of the line λ3820 of the diffuse subordinate series. Apparently the lines of this new series can only be observed in the presence of an electric field, and the ratio of their intensities to those of lines of other series depends on the strength of the field used. As regards the effect of the electric field in splitting up the lines, it is found that the components are approximately equally spaced, but the axis of symmetry is displaced about 1 Å.U. towards the violet from the original line. There is a marked similarity between the effects on the lines of this new series and on the lines of the diffuse subordinate series, both as regards number, separation, and intensity ratio of components, and dissymetric position of the original line. A sharp principal series with the formula $\nu = Ez(h) - Lz(m, s)$ has also been observed from the third to the sixth member, and again excellent agreement is found between calculated and observed wave-lengths. There is in this case practical identity, as regards the effect of the electric field, with the corresponding lines of the sharp subordinate series. There is thus the following system of series for He I :—

Diffuse principal series .... $\nu = Ez(h)_1 - Lz(m, d)_1$
Diffuse subordinate series..................... $\nu = Ez(n)_1 - Lz(m, d)_1$
Sharp principal series .... $\nu = Ez(h)_1 - Lz(m, s)_1$
Sharp subordinate series .... $\nu = Ez(n)_1 - Lz(m, s)_1$
Nearly sharp principal series .... $\nu = Ez(h)_1 - Lz(m, f)_1$
Nearly sharp subordinate series .... $\nu = Ez(n)_1 - Lz(m, f)_1$

He II would give another system of six series.

The correspondence of the Stark-effect for the different pairs of series is very remarkable, and should have some important applications to atomic theory. [See Abs. 1619 (1908), 235 and 1875 (1909).]
A. W.

1253. *Stark-effect for Ultra-violet Lines of Helium.* **G. Liebert.** (Ann. d. Physik, 56. 8. pp. 589–609, Sept. 20, 1918.)—The various series lines of helium in the ultra-violet have been investigated, and some interesting results are now given. For the principal series of He I, the lines are displaced by the electric field, as was previously found by Stark and Kirschbaum, towards the red, and the *p*-components show the same displacement as the *s*-components. The displacement is not, however, proportional to the field strength, but increases more quickly with greater fields. The second subordinate series behaves in a similar way. The remaining series are dealt with seriatim and the results are tabulated and graphed. It was found that the diffuse and sharp principal series for He II, like those for He I, only appear with sufficient intensity for observation in the presence of an electric field. Lines of these new series were observed and investigated. A remarkable fact observed with the He II diffuse principal series was that there are, for each member observed, just as many *p*- and *s*-components as the number of the line in question. The separation of the outer components increases, in all lines observed, as the series number of the line increases. As Stark found [see preceding Abs.] for the He I series, so it was found for the He II series that there is both qualitative and quantitative agreement as regards the effect of the electric field on the lines in corresponding pairs of series, such as the nearly sharp principal and nearly sharp subordinate series. This appears then to be a general law for the systems of series in helium. [See Abs. 1071 (1914) and 1658 (1915).] A. W.

1254. *New Helium Series.* **G. Liebert.** (Ann. d. Physik. 56. 8. pp. 610–616, Sept. 20, 1918.)—The new series here dealt with, if it exists at all, is not of sufficient intensity in the positive column or negative glow to be observed. It only appears with sufficient intensity for observation in strong electric fields. If λ_n denotes the wave-length of the *n*th member of the principal series, λ'_n that of the third subordinate series, the wave-lengths are connected by the relation $1/\lambda_n - 1/\lambda_1 = 1/\lambda'_n$. The wave-lengths calculated from this formula, using the known wave-lengths of the principal series, are 6685·2, 4912·2, 4384·9, 4142·8, there being, of course, no line corresponding to the first member of the principal series. Lines have been observed of wave-lengths λ4910·8, 4384·5, and 4143·4, which agree very closely with the last three calculated values. The Stark-effect for these lines was found to correspond with that for the corresponding members of the principal series. [See Abs. 1653 and 1667 (1915).] A. W.

1255. *Depth of Effective Plane in X-ray Crystal Penetration.* **F. C. Blake.** (Nat. Acad. Sci., Proc. 4. pp. 236–241, Aug., 1918.)—In determining the value of *h* by means of X-rays, Blake and Duane [see Abs. 291 (1918)] found by experiment that the "depth of the effective plane" was 0·203 mm. in the case of calcite, using X-rays of wave-length 0·454 Å. The "effective plane" was defined by Blake and Duane as that plane at which, if reflection for all the rays occurred at *that* plane *only*, the effect at the ionisation chamber would be the same as that which actually does occur due to the different reflections for all the planes of atoms playing any part.

An attempt is made in the present note to calculate the depth of the effective plane of calcite from theoretical considerations. The calculated value D = 0·201 mm. is in excellent agreement with that observed by Blake and Duane, namely 0·203 mm. A. B. W.

1256. *Absorption of X-rays in Copper and Aluminium.* **C. M. Williams.** (Roy. Soc., Proc. 94. pp. 567–575, Aug. 1, 1918.)—The method described appears to offer a reliable and accurate means of measuring the absorption coefficients of homogeneous X-rays in various materials and the wave-lengths of the rays employed. In the experiments the interference method of obtaining homogeneous beams was employed, a rock-salt crystal being used to analyse a beam of X-rays generated by a Coolidge tube. The ionisation chamber was divided longitudinally into two parts, the rays entering one part having passed through the absorbing screen, the direct rays passing into the second chamber. In this way a correction could be applied for fluctuations in the intensity of the beam reflected from the face of the rock salt into the two ionisation chambers.

Plotting μ/ρ against λ^3 gives a straight line in each case, with a pronounced break in the aluminium curve at wave-length $\lambda = 0{\cdot}49$ Å.U. A similar straight line with a break a little below that for Al also obtains for copper.

The results are in agreement with Owen's 5th power absorption law. The curves for log μ/ρ against log λ also bring out very clearly that discontinuities occur both for Cu and Al at wave-lengths 0·448 Å.U. and 0·49 Å.U. respectively. A. B. W.

1257. *Röntgen Ray Interference and Mixed Crystals.* **M. v. Laue.** (Ann. d. Physik, 56. 7. pp. 497–506, Sept. 10, 1918.)—Two theories are held by physicists with respect to the molecular structure of mixed crystals, namely: (1) The atoms of the different components are distributed according to chance about the points in the space lattice. (2) In the mixed crystal lattice there is a regular distribution throughout, only with much greater lattice constants than obtain in the corresponding single crystal. Vegard and Schjelderup [Abs. 696 (1917)] have described interference experiments which strongly support the former view. They take a mixed crystal of KCl and KBr, and, on the assumption of a definite regular point system, they state that one of the interference maxima to be expected is not to hand. The present author, on the ground that this maximum is very weak according to theory, opines that here error may arise. In consequence he now extends the theory of Röntgen-ray interference to include the case of mixed crystal structure. Section 1 of the paper deals with the average value of the intensity, and for this a general expression is obtained. In Section 2, this equation of average intensity is discussed. In consequence of thermal motion the single crystal gives scattered radiation, which is considerably increased in mixed crystals; the investigation of this phenomenon affords important evidence for deciding between the above two theories as to the differences in structure between mixed and single crystals. The author concludes that the division into 32 classes holds good also for mixed crystals. Section 3 contains a discussion of examples. H. H. Ho.

1258. *Atomic Structure and X-ray Spectra.* I. **A. Sommerfeld** (Phys. Zeits. 19. pp. 299–307, July 15, 1918.)—A mathematical paper divided into the following sections:—(1) Introduction; (2) General formula for the energy of a plane system of circular rings; (3) Energy of a system of circular rings inclined relative to one another; (4) The K_α line.

The calculated and observed values of ν/N for the K_α lines of the elements Mg, Br, Sn, and W, show remarkably good agreement. A. B. W.

RADIO-ACTIVITY.

1259. *Wave-length of Hard γ-Rays from Radium.* **K. W. F. Kohlrausch.** (Phys. Zeits. 19. pp. 345–349, Aug. 15, 1918.)—X-ray measurements have shown that the absorption coefficient μ, or the mass-absorption coefficient μ/ρ in any substance is related to the wave-length as indicated by the equation: $\mu/\rho = A\lambda^n$, where A and n vary according to the absorber; n generally lying within the limits 2·6 and 3. This relation only holds good outside the region of selective absorption. Barkla has shown that the equation holds at any rate up to a wave-length $\lambda \geqq 0{\cdot}6 \times 10^{-8}$ cm. Glocker [Abs. 528 (1918)] and Hull and Rice [Abs. 1249 (1916)] have proved its validity up to a wave-length $\lambda \geqq 0{\cdot}1 \times 10^{-8}$ cm.; Glocker inferring from absorption measurements of γ-rays from RaC that these γ-rays have a wave-length $= 0{\cdot}12 \times 10^{-8}$ cm., this value being in good agreement with the value $\lambda_{\text{RaC}} = 0{\cdot}13 \times 10^{-8}$ cm. given by Rutherford and Andrade as a result of measurements on the γ-ray spectrum of RaB and C.

In a previous paper the author has shown that the γ-rays from RaC are complex, consisting of two components. The results of measurements of μ/ρ for these two sets of rays, as well as for the γ-rays from RaB, are shown in the following table:—

γ-rays from	Absorber.			
	H_2O.	Al.	Cu.	Pb.
(1) RaC. μ_1/ρ	0·055	0·047	0·044	0·047
(2) RaC. μ_2/ρ	0·100	0·085	0·079	0·132
(3) RaB. μ_3/ρ	—	0·21	(0·20)[1]	0·41

[1] Measured in zinc.

The γ-rays (1) and (2) RaC have up to the present been assumed to be homogeneous radiation.

A. B. W.

HEAT.

1260. *Expansion of Glass Threads.* **M. So.** (Math. Phys. Soc., Tōkyō. Proc. 9. pp. 425–441, Sept., 1918.)—The author finds that, as a general rule, the elongation with rise of temperature of a thread of unannealed glass becomes smaller and smaller at a temperature of 200°–300° C., and that above the latter limit it contracts and then elongates suddenly as the plastic state is reached. With annealed glass, however, such a contraction is scarcely detected, but only the rapid elongation. The higher the softening temperature of the glass, the greater the contraction. The difference of elongation between annealed and unannealed glass at the point of max. contraction is of the order of 1/10,000 of the total length. It is also found that the number of interference fringes, and therefore the strain of the glass, becomes larger and larger with rise of softening temperature, and increase of the hardness of the glass, while the speed of disappearance of the rings is greatest at the temperatures near that of max. contraction. The longitudinal contraction can therefore be explained as due to release, by heating, of the strain set up in the glass when this is drawn and cooled without annealing. J. W. T. W.

1261. *Latent Heat of Fusion as the Energy of Molecular Rotations.* **K. Honda.** (Tôhoku Univ., Sci. Reports, 7. pp. 123–130, Sept., 1918. Twenty-first Report of the Alloys Research Inst.)—In the theory of specific heat of a solid, it is usually assumed that each molecule (or atom) of a substance vibrates about the mean position with three degrees of freedom. Since the motion of each molecule is vibration, but not uniform translation, its total energy is just twice the mean kinetic energy during a complete period of vibration. Hence the energy on the quantum hypothesis belonging to each degree of freedom is given by $\epsilon_T = h\nu/e^{h\nu/kT} - 1$, where T is the absolute temperature, k the gas-constant referred to one molecule, h the universal constant, and ν the frequency of vibration. The author believes himself justified in assuming that with the above mode of rectilinear vibration the molecules (or atoms) are associated with small dependent rotational vibrations about their centres of mass, probably with a common period of vibration. At ordinary temperature, this mode of rotational vibration is very small, but as the temperature becomes higher it increases at a steady rate. The fact that at very high temperatures the specific heat experimentally found is in many cases greater than the theoretical value 5·96, indicates the presence of this rotational vibration. In approaching the melting-point of a substance, the amplitude of this vibration attains such a value that the rotational vibration at last becomes a continuous rotation. In the case of a cubic crystal, it is possible that this limiting half-amplitude is a little less than $\pi/4$. As soon as the rotational vibration is changed into a continuous rotation, the regular spacing of the molecules breaks down, disorder beginning to take place, and therefore the rotation becomes independent of the translation. The molecules thus set free have now 2 or 3 degrees of freedom for rotation; the angular velocity of each component rotation increases to such an extent that its energy becomes equal to that corresponding to one degree of freedom of rotation, *i.e.* $\frac{1}{2}\epsilon_{T_m}$, where T_m is the melting-point. If all the molecules undergo the above change, the fusion is completed and the crystal changed to a liquid. The author shows that E_{T_m}/T_m has a value a little less than $R = 1{\cdot}98$, where E_{T_m} is the total energy received by the molecules, also that $w\lambda/T_m = nE_{T_m}/2T_m$, where λ is the latent heat of fusion and w the molecular weight. Tables of data are given for showing whether in the case of elements the above simple relation is actually satisfied or not. For the elements Pt, Pd, Fe, Ni, Cu, Ag, Al, Zn, Pb, Cd, Tl, S, Na, K, P, and Hg, the relation is well satisfied, though their melting-points vary from 2028° K. to 234° K. Variations are found in the cases of Bi, Sn, I, Ga, Br, and Cl, since $w\lambda/T_m$ has a much greater value than $nE_{T_m}/2T_m$. It has to be noticed, however, that the elements Bi and Ga appear to undergo a transformation during melting, because their electric resistance also diminishes during melting, which is an abnormal phenomenon. Similarly with regard to Sn, whose sign of magnetic susceptibility changes abnormally during melting. It is to be concluded that unless some transformation takes place in a substance during fusion, or its specific heat is abnormally large (as in the case of the halogens), the latent heat of fusion consists of the energy of rotation of the molecules, gained during fusion. A similar relation holds good for compounds, although the ratio $w\lambda/T_m$ is generally much greater than in the case of elements. Data are given for KOH, NaOH, RbOH, CsOH, and AgBr, where if 3 degrees of freedom for rotation be assumed, then the values of $w\lambda/T_m$ nearly coincide with those of $nE_{T_m}/2T_m$. For the compounds KF, NaCl, KCl, TlBr, AgCl, TlCl, $BaCl_2$, $CaCl_2$, $PbCl_2$ and $PbBr_2$, 5 to 7 degrees of freedom for rotation are assumed, and then the agreement between the said ratios is fairly good. H. H. Ho.

1262. *Inflammation of Methane-Air Mixtures.* **R. V. Wheeler.** (Chem. Soc., J. Trans. 113. pp. 840-859, Nov., 1918.)—Experiments on the pressure development and rate of flame propagation have been made in spherical vessels of cast bronze, 19·5 and 31·2 cm. diam., 4 and 16 litres capacity. The max. pressure observed was in both vessels 6·97 atmos. (above atmospheric) in mixtures containing about 10 % of methane. The values are lower than the irregular values of le Chatelier and Mallard (1883, cylindrical vessel, 17 cm. diam. and length), and agree better with those of Beyling (1906, cylinders of 11 and 42 litres). The ignition by electric sparks was central as with le Chatelier; since in a cylindrical vessel the ignition wave would probably strike some portions of the walls earlier than others, a correction for this effect is discussed, and experiments are also made on the flame propagation in cylindrical vessels. In all mixtures containing from 7·5 to 12·5 % of methane the propagation-rates upward and downward were identical; in mixtures outside this range the flame travelled faster upward, *e.g.* in 0·26 sec. against 0·468 sec. downward. The max. pressure (recorded by the style of a steel strip, 2·6 mm. thick) need not be the actual maximum attained. Apart from the heat losses by conduction and radiation, the products of combustion are not in thermal equilibrium. The pressure first increases rapidly, then keeps constant, and gradually decreases in the third period owing to cooling. The second constant period might be ascribed to successive stages in the combustion, to exothermic secondary reactions between steam and carbon monoxide (Bone), and to equalisation of temperature. But this second period was nearly twice as long in the big as in the small vessel, and experiments suggest that it is mainly a consequence of temperature equalisation. There is, moreover, a time-lag between the moment of ignition and the first indication of pressure (as Bairstow and Alexander showed in 1905), amounting in a 6·30 % methane mixture in which the flame travelled at 28 cm. per sec. to 0·18 sec., while the max. pressure was reached after 0·848 sec. in the small vessel; in the large vessel, at 15 cm. flame-speed, these figures were 0·422 and 1·087 sec. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY

1263. *Remark on Electron Charge Experiments by I. Parankiewicz.* **R. Bär.** (Phys. Zeits. 19. p. 378, Sept. 1, 1918.)—Referring to the work of I. Parankiewicz [Abs. 188 (1918)] in which it was concluded, from experiments on spherules of sulphur, selenium and mercury, that the electron charge was of the order 10^{-13}, the present author, using the formula of E. Weiss (1911), holds that from the Brownian motions the calculated values of the charges of the smallest ultramicroscopic particles yet observed are throughout of the order of Millikan's value for the electron charge. E. H. B.

1264. *Ions produced by bubbling Air through Alcohol.* **J. A. McClelland** and **P. J. Nolan.** (Royal Irish Acad., Proc. 34. pp. 51–61, Aug., 1918.)—For the abstract see Abs. 1182 (1918).

DISCHARGE AND OSCILLATIONS.

1265. *The Origin of Kathode Rays.* **E. Meyer** and **H. Schüler.** (Ann. d. Physik, 56. 7. pp. 507–528, Sept. 10, 1918.)—From their observations on the phenomenon produced when a body, impenetrable to kathode rays, is placed in the kathode dark space, Schuster, Villard, Wehnelt, and Stark have drawn the conclusion that the emission of kathode rays is dependent on the impact of canal rays on the kathode. It follows from this hypothesis that the kathode dark space may be deflected by a magnetic field. The observations of the phenomenon, described in the present paper, not only give qualitative support to this theory, but are also in good quantitative agreement. The observed curvatures of the "dark space" are in excellent agreement with the calculated values. A. B. W.

1266. *Low-voltage Discharge in Sodium Vapour.* **P. D. Foote** and **F. L. Mohler.** (Washington Acad. Sci., J. 8. pp. 513–515, Sept. 19, 1918.)—Various considerations lead to the conclusion that the shorter wave-length D_2 of the sodium spectrum might be expected to appear at the resonance potential of 2·10 volts, the wave-length D_1 not appearing until the ionisation potential of 5·13 volts is reached. Experiments showed that a visible yellow glow could be detected when the accelerating potential was as low as 0·8 volt. This shows that a considerable number of the electrons emitted from the hot kathode must have had an initial velocity of about 1·3 volts. As the voltage increased, the intensity of the discharge rapidly increased. At an applied potential of 5·2 volts the character of the arc changed entirely, the second subordinate series of sodium appearing, thus indicating ionisation; and the arc became very brilliant. The applied potential of 5·2 volts is nearly the same as the ionisation potential, and hence the initial velocity of the greater portion of the electrons emitted from the kathode could not have been as high as 1·3 volts. At an applied potential of 2 volts, a true potential certainly not greater than 3·3 volts, the two D lines were distinctly visible, and as nearly as could be judged, the ratio of their intensities remained about the same as the applied voltage was decreased to 0·8 volts, when both lines disappeared. It thus appears that the two D lines appear together at the resonance potential. It may be, however, that the lines are separately excited by electronic impact, as is shown by the work of Wood and Mohler, the influence of the surrounding vapour causing a transfer of energy from the excited line to the other component of the doublet. A. W.

1267. *Theory of the Thermionic Amplifier.* **H. J. van der Bijl.** (Phys. Rev. 12. pp. 171–198, Sept., 1918.)—This paper gives an outline of the mathematical theory of all points connected with the operation of amplifying devices of the 3-electrode type. It deals successively with (1) Current-voltage characteristics of simple thermionic devices; (2) Effect of residual gas on the characteristic; (3) Action of the auxiliary electrode; (4) Current-voltage characteristic of the thermionic amplifier; (5) Experimental verification of the characteristic equation; (6) Characteristic of circuit containing thermionic amplifier and ohmic resistance in series; (7) Amplification equations of the thermionic amplifier; (8) Experimental verification of amplification equations. It is shown that by proper choice of the structural parameters, tubes may be (and have been) designed to give voltage or power amplification covering a wide range. A voltage amplification of several hundred-fold is not difficult to obtain, while a power amplification of 8000-fold was found possible, using an anode voltage of only about 100 volts. Tubes used as wireless detectors can be designed to operate on very low voltages, a very efficient type of detector having been made to give satisfactory operation with 2 volts on the filament and an anode voltage of 12 volts or less. The structure of the device is a particularly important function, since on it depend the constants involved in the amplification equations, and which are involved explicitly and implicitly in the fundamental equation of the characteristic.

A. W.

1268. *Effect of Transverse Magnetic Field on the Discharge through a Geissler Tube.* **J. E. Ives.** (Phys. Rev. 12. pp. 293–313, Oct., 1918.)—During the course of some recent investigations on the so-called magnetic rays of Righi [Abs. 806 (1917)], it became necessary to determine the effect of a transverse magnetic field on the discharge through the Geissler tube used. It was found that the current through the tube was increased, and the p.d. across the tube decreased by the field. When the strength of the field was further increased, the discharge became periodic for a certain value of the field, and finally ceased altogether when the field, being still further increased, reached a certain value. The results obtained by other investigators as regards the effect of a transverse field on a Geissler tube are somewhat contradictory, so the subject has been further investigated. The discharge tube employed was 1·5 cm. in diam., with the electrodes of Pt wire 7·5 cm. apart. The contained air was at a pressure of 0·13 mm. In such conditions the effect of a transverse magnetic field upon the discharge, when acting on the kathode region only, is to increase the current through the tube; when acting on the anode region only, to decrease it; and when acting on the whole tube, to increase it. The ampere-gauss curve for the field acting on the kathode region only is a modified exponential curve of the form obtained by Townsend for increasing length of path. The ampere-gauss curve for the field acting on the anode region only is a descending straight line. The ampere-gauss curve for the field acting on the whole tube is, to a first approximation, the sum of the curves for field acting on the kathode region only and for field acting on the anode region only. When a magnetic field acts on a tube, the external variables of its circuit being kept constant, the potential across the tube and the current through it vary oppositely, one decreasing when the other increases according to the equation $e = E - iR$, where e is the p.d. across the tube, i the current through it, E the impressed e.m.f., and R the external resistance of the circuit. If the p.d. is plotted as a function of the current, we thus get a straight line whose slope is equal numerically to R. The amplitude of the ampere-gauss or volt-gauss curve is affected by the value of the external resistance, R, of the circuit. The amplitude of the ampere-gauss curve is decreased by increasing R, and that of the volt-gauss curve is increased. The volt-ampere characteristics of the tube were determined for magnetic fields of different strengths. The characteristic for a magnetic field of a given strength crosses the characteristic for zero field at a certain critical value of the current, which differs for different values of the field. For values of the current less than the critical value, the current is increased by the action of a transverse field, while for values greater than the critical value it is decreased. A. W.

1269. *Capacity-Potential Curves of an Induction Coil.* **E. T. Jones.** (Electrician, 81. pp. 376–378, Aug. 30; 396–397, Sept. 6, and pp. 416–418, Sept. 13, 1918.)—An expression is given for the max. secondary potential of an induction coil calculated on the theory that two oscillations are set up in both primary and secondary circuits when the former is interrupted [see Abs. 1022 (1917)]. The relation between (1) the primary capacity and the secondary potential, (2) the max. efficiency of conversion of electromagnetic energy in the primary into electrostatic energy in the secondary and the coefficient of coupling, is shown by calculated and experimental curves. The present results are compared with those found in previous experiments on the relation between capacity and spark-length. The uses of capacity-potential curves in the determination of the constants of induction coils are discussed, and examples are given of the calculation of optimum capacities. A repetition of Rayleigh's rifle-bullet experiment is described, the result obtained confirming the theory put forward by the author. N. W. M.

1270. *Harmonics of a Lecher System: Experimental.* **F. C. Blake** and **B. H. Jackson.** (Ohio J. of Sci. 18. No. 5. pp. 145–162, March, 1918.) *Theoretical.* **F. C. Blake.** (*Ibid.* pp. 163–168, March, 1918.)—The authors determined experimentally the relation between the tone intensity and the distance between the plates edge-on and have found the best distance Ys for a tone of a given frequency-number s to fulfil an empirical relation. A theory to account for the observed effects is developed in the second paper. [See Abs. 588 (1917).] E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1271. *Electrical Conductivity of Vertically Suspended Wires.* **S. R. Williams.** (Phys. Rev. 12. pp. 248–250, Sept., 1918.)—Under a similar title, S. Bidwell showed in 1887 that the electrical resistances of vertically suspended copper and iron wires alter to a small extent with the direction of the current traversing them. He found that the resistance of a copper wire is slightly greater when the current is up than when it is down. On the other hand, a temporarily stretched iron wire appeared to have a greater resistance for a down current than for one flowing up.

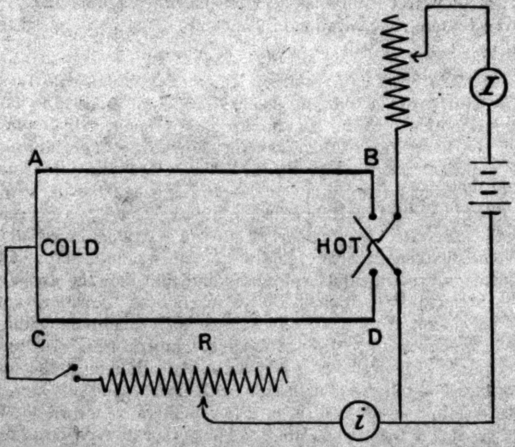
The present work confirms that of Bidwell, both as to the character of the effect and as to the explanation of it. E. H. B.

1272. *On the Resistance of certain Novel Conductors.* **K. Lichtenecker.** (Phys. Zeits. 19. pp. 374–382, Sept. 1, 1918.)—The work of Guertler, Benedicks, and the present author [see Abs. 458 (1910)] has rendered necessary the evaluation of the resistance of certain superficial conductors. Guertler was the first to treat the problem of the resistance presented by a conductor built up as a space lattice, the component parts being arranged similar to a chess-board. Guertler's work is first described in some detail, and is extended by the present author to explain the behaviour of metallic alloys belonging to the group free from mixed crystals. The values calculated from the models are found to be in good agreement with those obtained by Matthiessen for the alloys. The paper contains: (1) A short summary of published work on the resistance of artificial and natural alloys. (2) The calculation of the resistance, including upper and lower limits, of a conductor constructed like a chess-board. The experimental values for this have been worked out by C. Benedicks. (3) A collection, (*a*) of the resistance values given by model experiments; (*b*) of the theoretical limiting values for specially constructed models; (*c*) of the values found by Benedicks by an alternative method. From these collected data the following principles are deduced:—(4) The measured resistances as given by Benedicks lie not only outside the values established by Guertler, but also outside the theoretical resistance limits for the case considered in this paper. (5) The values, however, given for the chess-board model lie within the Guertler intervals. (6) For any homogeneous and isotropic aggregate of conductor particles it is shown and calculated, for the case of 50 % volume concentration, that the theoretical limits of resistance agree with those of the isometric model. (7) The resistance of an alloy, with exclusion of secondary phenomena such as mixed crystal formation, can neither be a linear function of the resistances of the components nor a reciprocal linear function of their conductivities. The resistance of alloys free from mixed crystals is, rather, a function whose values for a given volume concentration of the components lie between the values rendered by each of the above simple functions. H. H. Ho.

1273. *On the Change in Resistance of Monatomic Metals with Temperature.* **E. Grüneisen.** (Phys. Zeits. 19. pp. 382–387, Sept. 1, 1918.)—This paper is an extension of a previous communication on the electric conductivity of metals at low temperatures. It was then shown from a series of examples that the empirical relationship $w \sim T \,.\, F(T/\theta_r) \,.\, C_p/C_v$ held for monatomic metals over a wide range at low temperatures, when the derived form of function for F, as given by Debye for the atomic heat C_v, is chosen, and θ_r fits in with resistance observations. Differences occur, however, between the characteristic temperatures θ_r and θ_c (for the atomic heats) which cannot be explained as experimental errors, and indicate that the above function cannot be identical with that of Debye when both the above are closely related. The factor C_p/C_v appears insufficient for maintaining the proportionality between w and T . F at higher temperatures. In the earlier work the metals chosen showed only small deviations and the expression was valid, but it is otherwise with iron and nickel. In the latter cases the above relationship does not hold, even at low temperatures, owing to the rapid change of resistance with temperature. The author now proposes to replace C_p/C_v by a temperature function which holds good at higher temperatures, and then to investigate whether the proportionality between resistance and $T \,.\, F(T/\theta_r)$ holds good at lower values. The amended formula is $w \sim T \,.\, F(T/\theta_r) \,.\, [1 + a_1 T + a_2 T^2]$ and the experimental results are found to justify the assumption. This expression with two constants has been found so exact for platinum as to have not only the value of an interpolation formula, but to suggest a theoretical foundation. Experimental data are given and discussed for Pb, Au, Fe, and Pt. For the first three metals α_1 and α_2 are both positive, although their magnitudes are very different. Iron, for instance, has coefficients 10 times greater than gold, while lead takes an intermediate position. Platinum has positive α_1 but negative α_2. Tables and illustrative curves accompany the paper. H. H. Ho.

1274. *Conductivities and Thermoelectric Powers of Bismuth-Tin Alloys.* **A. E. Caswell** and **C. A. McKay.** (Phys. Rev. 12. pp. 226–230, Sept., 1918.)—To test the theory of the Peltier-effect as given by J. J. Thomson and Drude, Caswell has used experimental data obtained by him in the case of Bi and alloys of Bi and Sn [Abs. 602 (1916)]. As those specimens were not sufficiently uniform for resistance measurements, data for the conductivity were taken from the results of Schultze on Bi-Sn alloys of the same percentage composition. The conclusion was drawn that the experimental data conformed better to the theory of Drude than to that of Thomson. In the present paper a more uniform set of specimens has been prepared and both the resistance and Peltier-effect measured. The addition of a very small quantity of Sn is found to increase the resistance considerably, but with further addition the resistance decreases. It would also appear, and especially for alloys with a small percentage of Sn, that the theoretical equation of Thomson for the thermoelectric power is preferable to that of Drude. L. L.

1275. *Thomson-effect in Bismuth-Tin Alloys.* **A. E. Caswell.** (Phys. Rev. 12. pp. 281–287, Sept., 1918.)—A preliminary account of a compensation method for measuring the Thomson-effect. In the Fig. AB, CD are two exactly similar bars of the metal under test. A current being passed in the direction BACD, that in the branch CD may be reduced by adjusting the shunt resistance R until the temperature gradients in the two bars are identical. Then $\sigma = i\gamma/I$, where γ is the resistance per unit length of the



bars and t the temperature gradient in degrees per unit length. In practice, exact adjustment for identical temperature gradients is not possible, but a more exact expression for σ is given in the paper when the temperatures at corresponding points on the bars are known. At present the design of the apparatus is not perfect, but some preliminary measurements for Bi and for Bi-Sn alloys have been made. At a mean temperature of 48·5° C. the author gives the following values :—

Sn percentage…………………………	0	1·00	2·00	3·72	6·36
Thomson-effect, microvolts per 1 deg. C.	58	676	587	207	137

L. L.

1276. *Experiments on the Effect of the Vibration of a Stretched Wire forming Part of a Closed Electric Circuit.* **H. Jackson.** (Roy. Soc., Proc. 95. pp. 51–57, Sept. 2, 1918.)—Wires of various materials, of different lengths and under varying tensions, were connected with a battery and the primary of the step-up transformer of a 3-valve amplifier. The secondary winding of the third valve led to a pair of 60-ohm Brown telephones at some considerable distance. Musical notes and various noises sounded near the wire could be easily differentiated at the telephone although speech was not intelligible. The arrangement responded as the current through the wire was reduced, showing that the microphonic effect could not be ascribed to excess of temperature of the wire above the surrounding air. Varying the relative position of the wire with respect to the earth's field convinced the author that the effect was not due to the vibration of the wire in the earth's magnetic field. Endurance tests showed that steel piano wire (No. 28 S.W.G.) was most consistent and responsive. According to the author's view the experiments seem to confirm a suggestion made by Marrian that a mechanical vibration would produce a current. L. L.

ALTERNATING CURRENTS AND MAGNETISM.

1277. *The Diamagnetism of Hydrogen and the Value of the Magneton.* **A. E. Oxley.** (Roy. Soc., Proc. 95. pp. 58–61, Sept. 2, 1918.)—The author has previously brought forward evidence to show that the magneton may be a constituent of diamagnetic substances. The elements of magnetism would be arranged in such a way that the molecule is self-compensated and a diamagnetic effect would result on the application of an external field. The moment of the electron orbit in a diamagnetic molecule is then calculated on the electron theory and found to be $14·7 \times 10^{-22}$. This differs by about 15 % from the moment of the Weiss magneton in the molecules of ferro- and paramagnetic substances. On the author's view a hydrogen molecule would consist of two atoms, each with a single electron. These electrons may revolve in opposite directions, giving a diamagnetic molecule. Although the stability of such a system is impossible from the ordinary point of view, it may accord with the more recent quantum view of atomic stability. If diamagnetic substances contain magnetons it would help to account for the fact that the chemical combination of diamagnetic substances can give rise to paramagnetic substances containing magnetons. If the magneton is a constituent of the H atom, the radius of the electron orbit is calculated as 1×10^{-8} cm. L. L.

1278. *The Hall-effect.* **M. La Rosa** and **U. De Luca.** (N. Cimento, 15. pp. 89–99, Jan.–Feb., 1918.)—The nature of the secondary electrodes makes remarkable differences in the Hall-effect. Experiments are in progress to trace the cause of this. A. D.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1279. *The Adsorption of Gases on Plane Surfaces of Glass, Mica, and Platinum.* **I. Langmuir.** (Am. Chem. Soc., J. 40. pp. 1361–1403, Sept., 1918.)—According to a theory put forward by the author, the adsorbed film should not, in typical cases, exceed one molecule in thickness. This view is contrary to that usually held, and the discrepancy is accounted for by the fact that nearly all investigators have worked with porous bodies in which the adsorbing surface is indeterminate, or have used nearly saturated vapours so that condensation of liquid occurred in capillary spaces. Others have mistaken solution or absorption for true adsorption. According to the author, the forces causing adsorption are typically chemical and exhibit all the great differences in intensity and quality characteristic of chemical forces. The adsorption of so-called permanent gases by solids usually involves only secondary valency forces, but a great many cases of adsorption, particularly by metals, are caused by primary valency forces. Although equations can be developed which give the relation between the amount of adsorbed gas and the pressure and other variables under various assumed conditions, no single equation, other than purely thermodynamic ones, could be expected to cover all cases of adsorption any more than a single equation should represent equilibrium pressures for all chemical reactions.

At room temperature the adsorption of common gases by mica and glass is negligible, certainly not over 1 % of the surface being covered by a single layer of molecules. At $-183°$ and at $-118°$ C. relatively large amounts of gas are adsorbed, except in the case of hydrogen. The max. quantities adsorbed even with saturated surfaces were always somewhat less than the amounts to be expected in a monomolecular layer. The amounts of the different gases adsorbed by saturated surfaces of mica and glass were always in the following order: hydrogen, oxygen, argon, nitrogen, carbon monoxide, methane, and carbon dioxide. The amounts of these gases adsorbed by mica and glass varied with the pressure in accordance with the equation $N/N_0 . \eta = \theta_1 = \sigma_1\mu/(1 + \sigma_1\mu)$, where η is the number of gm. molecules of gas adsorbed per unit area of surface, N_0 the number of elementary spaces per cm.^{2} of surface, N is the Avogadro constant, $6{\cdot}06 \times 10^{23}$ molecules per gm. molecule, σ is the "relative life" of an atom of adsorbed gas on the surface, and μ is the number of gm. molecules of gas striking each cm.^{2} per sec.

The phenomena observed with platinum were quite different. No adsorption of gases could be observed even at $-183°$, until the Pt had been "activated" by heating to 300° in a mixture of hydrogen and oxygen at low pressure. After this activation, hydrogen and oxygen or CO and oxygen reacted together readily at room temperature in contact with platinum. The Pt was then found capable of adsorbing oxygen, CO, or hydrogen. The max. quantities of oxygen and CO corresponded to monomolecular layers. When the Pt was in contact with an excess of oxygen the amount of oxygen adsorbed increased as the temperature was raised, but the action was irreversible. Adsorbed carbon monoxide could not be removed by pumping at room temperature, but at 300° part of it could be pumped off. When oxygen was brought in contact with CO adsorbed on the Pt, it reacted rapidly to form CO_2, which at room temperature showed no tendency to be adsorbed on the platinum. These cases of adsorption are clearly due to chemical forces of the primary valence type. Further work needs to be done to determine the cause of the activation of the platinum. A. F.

1280. *The Heterogeneity of Steel.* **H. le Chatelier** and **B. Bogitch.** (Comptes Rendus, 167. pp. 472–477, Sept. 30, 1918.)—The macrostructure developed in a steel by etching with a copper reagent such as that of Stead has hitherto been ascribed to heterogeneity in the distribution of the phosphorus. The same structure can, however, be developed in steels free from phosphorus, and it is suggested by the authors that oxygen, remaining in solution as FeO, is the real cause. That FeO can be present in solid solution is shown by the fact that the electrical resistance of steels which have not been completely deoxidised is higher than it should be, after making due allowance for the presence of each of the known impurities in the material. F. C. T.

1281. *Cementite Transformation and the Equilibrium Diagram of the Iron-Carbon System by Means of Electric Resistance Measurement.* **I. Iitaka.** (Tôhoku Univ., Sci. Reports, 17. pp. 167–175, Sept., 1918. Twenty-third Report of the Alloys Research Inst.)—By means of a differential method of measurement a charge of electrical resistance was observed for Fe_3C at the A_0 point. On heating, the mean temperature was 205° C., and on cooling 197° C. The equilibrium diagram of the steels containing up to 1·5 % C has been determined by electric resistance measurements for both heating and cooling, and in particular the "cementite" line for the steels containing more than 0·9 % C.

Carbon in Steel. Percentage.	Acem. (Heating).	Acem. (Cooling).
1·07	895° C.	805° C.
1·26	985°	965°
1·30	990°	975°

F. C. T.

1282. *Effects of Cold Work on the Elastic Properties of Steel.* **J. A. van den Broek.** (Iron and Steel Inst., Carnegie Schol. Mem. 9. pp. 125–165; Disc., 166–169, 1918. Engineering, 106. pp. 99–105, July 26, 1918.)—Cold work is defined as any process which causes permanent change of shape of steel at any temperature below the critical point. In order to study the subject in its broadest aspect, mild steel has been cold-stretched, cold-compressed, and cold-twisted, and the effects on the elastic properties in tension, compression, and torsion have been determined. Ageing and tempering at boiling-water temperatures has also been investigated. The effects of cold-working on the elastic properties of steel appear to be independent of the stresses involved in the cold-working process, but seem to be functions of the strains produced in cold-working, regardless of how such strains are brought about. Cold-twisting modifies both the tensile and compressive elastic properties in a similar manner. Just as cold-stretching raises the elastic limit in tension, so cold compression raises the elastic limit in compression. If steel is tested in the direction in which it was worked very soon after cold-working, the elastic limit is lowered, often down to zero; but if the specimen be tempered at 100° C. the elastic limit is raised from 10–20 % beyond the stress at which cold work was discontinued. Ageing has a similar but slower effect, but it is believed that with sufficient time it will result in the effect as tempering at 100° C. When within 10 mins. of cold-working a specimen is tested in a direction opposite to that in which it was cold-worked, the elastic limit is seen to be zero. Partial recovery occurs after a few days' ageing, but after heating to 100° C. or above, the elasticity of the specimen is improved. Cold stretching does not permanently lower the elastic limit in compression. Earlier contradictory results on this point appear to be due to the fact that the significance of ageing and tempering has not been properly recognised. Cold work has no effect on the electrical resistivity of steel. The author discusses the amorphous cement theory, and points out that the crushing strength of polished steel balls is greater than that of unpolished balls or of polished balls which have been subsequently etched. With regard to the commercial aspects of cold-working, the author points to the increased strength of reinforced concrete beams by the use of cold-twisted bars and the possibility of utilising for shafting the large increase in torsional elastic limit brought about by cold-twisting. It is essential that in such cases the elastic properties should be perfected by tempering at boiling-water temperatures or above. The effects of cold work upon the elastic properties of steel are permanent. F. C. A. H. L.

1283. *Temperature Uniformity in an Electric Furnace.* **J. B. Ferguson.** (Phys. Rev. 12. pp. 81–94, July, 1918.)—The author discusses the various methods which have been employed for obtaining uniformity of temperature distribution in an electric furnace. In the type of furnace described in the present paper the windings consist of two independent sections: (1) a uniform winding over the central area with uniform or crowded ends; (2) two plugs inserted in the ends of the furnace with crowded or uniform windings. The function of the plugs is to reduce the end losses by radiation, which are of considerable magnitude at high temperatures. The plug itself consists of two coaxial cylinders of alundum, with alundum disc ends. The winding is on the smaller tube, the space between being filled with ignited magnesia powder. It is necessary to have three independent electrical controls, although the current required by the end heaters will usually be very nearly of the same magnitude.

In the case of the 45-cm. long furnace, a uniformly heated region 6 cm. in diameter and 10 to 12 cm. in length was obtained, with a variation of less than ± 0·5 deg. C. at temperatures from 600° to 1200° C. E. G.